Part 1.
Please circle the correct answer, to the nearest number for the quantitative questions. Each Question worth’s 1 point.

1. Two uncharged conducting spheres, A and B, are suspended from insulating threads so that they touch each other. While a negatively charged rod is held near, but not touching sphere A, someone moves ball B away from A. How will the spheres be charged, if at all?

(A) 0 +
(B) – +
(C) 0 0
(D) – 0
(E) + –

2. One mole of a substance contains \(6.02 \times 10^{23}\) protons and an equal number of electrons. If the protons could somehow be separated from the electrons and placed in very small, individual containers separated by \(1.00 \times 10^3\) m, what would be the magnitude of the electrostatic force exerted by one box on the other?

(A) deficiency, \(6 \times 10^{13}\)
(B) excess, \(2 \times 10^{13}\)
(C) deficiency, \(1 \times 10^{12}\)
(D) excess, \(3 \times 10^{13}\)
(E) deficiency, \(3 \times 10^{12}\)

3. At which point (or points) is the electric field (N/C) zero for the two point charges shown on the \(x\) axis?

(A) The electric field is never zero in the vicinity of these charges.
(B) The electric field is zero somewhere on the \(x\) axis to the left of the \(+4q\) charge.
(C) The electric field is zero somewhere on the \(x\) axis to the right of the \(-2q\) charge.
(D) The electric field is zero somewhere on the \(x\) axis between the two charges, but this point is nearer to the \(-2q\) charge.
(E) The electric field is zero at two points along the \(x\) axis; one such point is to the right of the \(-2q\) charge and the other is to the left of the \(+4q\) charge.

4. Four point charges are placed at the corners of a square as shown in the figure. Each side of the square has length 2.0 m. Determine the magnitude of the electric field at the point P, the center of the square.

(A) \(2.0 \times 10^{-6}\) N/C
(B) \(1.8 \times 10^{4}\) N/C
(C) \(2.7 \times 10^{4}\) N/C
(D) \(3.0 \times 10^{-6}\) N/C
(E) \(9.0 \times 10^{4}\) N/C

5. What is the electric flux passing through a Gaussian surface that surrounds a \(+0.075\) C point charge?

(A) \(8.5 \times 10^{9}\) N-m\(^2\)/C
(B) \(1.3 \times 10^{7}\) N-m\(^2\)/C
(C) \(7.2 \times 10^{5}\) N-m\(^2\)/C
(D) \(6.8 \times 10^{8}\) N-m\(^2\)/C
(E) \(4.9 \times 10^{6}\) N-m\(^2\)/C
6. Which one of the following statements best explains why it is possible to define an electrostatic potential in a region of space that contains an electrostatic field?

(a) Work must be done to bring two positive charges closer together.
(b) Like charges repel one another and unlike charges attract one another.
(c) A positive charge will gain kinetic energy as it approaches a negative charge.
(d) The work required to bring two charges together is independent of the path taken.
(e) A negative charge will gain kinetic energy as it moves away from another negative charge.

7. Two positive point charges are separated by a distance $R$. If the distance between the charges is reduced to $R/2$, what happens to the total electric potential energy of the system?

(A) It is doubled.  (B) It is reduced to one-half of its original value.
(C) It remains the same. (D) It is reduced to one-fourth of its original value.
(E) It increases by a factor of 4.

8. A charge $q = -4.0 \, \mu C$ is moved 0.25 m horizontally to point P in a region where an electric field is 150 V/m and directed vertically as shown. What is the change in the electric potential energy of the charge?

(A) $-2.4 \times 10^{-3}$ J  (B) $+1.5 \times 10^{-4}$ J  (C) $-1.5 \times 10^{-4}$ J
(D) $+2.4 \times 10^{-3}$ J  (E) zero joules

9. Which one of the following changes will necessarily increase the capacitance of a capacitor?

(A) decreasing the charge on the plates
(B) increasing the charge on the plates
(C) placing a dielectric between the plates
(D) increasing the potential difference between the plates
(E) decreasing the potential difference between the plates

10. A 10-A current is maintained in a simple circuit with a total resistance of 200 $\Omega$. What net charge passes through any point in the circuit during a 1-minute interval?

(A) 200 C  (B) 500 C  (C) 1200 C  (D) 400 C  (E) 600 C

11. Determine the length of a copper wire that has a resistance of 0.172 $\Omega$ and cross-sectional area of $1 \times 10^{-4}$ m$^2$. The resistivity of copper is $1.72 \times 10^{-8} \, \Omega \cdot m$.

(A) 0.1 m  (B) 100 m  (C) 10 000 m  (D) 10 m  (E) 1000 m.

*End of part 1.*
**Part 2. Please show your work in the space provided.**

1. Three charges are located along the x axis as shown in the drawing. The mass of the $-1.2 \, \mu\text{C}$ is $4.0 \times 10^{-9} \, \text{kg}$. Determine the magnitude and direction of the acceleration of the $-1.2 \, \mu\text{C}$ charge when it is allowed to move if the other two charges remain fixed. 

   (2 points)

   ![Diagram of three charges along the x axis](attachment://diagram.png)

   (b) $1 \times 10^5 \, \text{m/s}^2$, to the left

   **Answer (with units):**

2. How much energy is stored in the combination of capacitors shown? 

   (2 points)

   ![Diagram of capacitors](attachment://capacitors.png)

   (c) $0.03 \, \text{J}$

   **Answer (with units):**
3. Three resistors and two 10.0-V batteries are arranged as shown in the circuit diagram. What is the power delivered to the 12 \( \Omega \) resistor?

\[ \text{(2 points)} \]

Answer (with units): 

\[ \text{________________________} \]

End of part 2.

Some useful constants: \( e^- = 1.60 \times 10^{-19} \) C., \( \varepsilon_0 = 8.85 \times 10^{-12} \) C\(^2\)/N.m\(^2\),
\( k = (1/4\pi\varepsilon_0) = 8.99 \times 10^9 \) N.m\(^2\)/C\(^2\), \( m_e = 9.11 \times 10^{-31} \) kg, \( m_p = 1.67 \times 10^{-27} \) kg.

Good Luck